MMDA use of JTRS Architecture

Michael Kocin

May, 2005

Functional Approach: What is an MMDA

- **Multi-Mode**
  - *Multiple Modes of a Single Radio Type in a Single LRU*
- **Multi-Function**
  - *More than one Communication Function in LRU (Enclosure)*
  - *Communication, Navigation and/or Surveillance Functions in a single LRU*
- **A Software Defined Radio simulates (and communicates) multiple waveforms that provide interoperability with fielded qualified radio's**

Utilize Common Hardware and Software Architecture for future enhancements

Need for MMDA

- Accelerating pace of new and more complex waveforms
- Cost of Qualification of New waveforms
- Cost of Re-qualification for existing hardware and software for upgrades and modifications
- Increased cost of new system development and qualification
- Re-configurability of avionics systems for various geo locations
- Over Ocean Communications
- Air Traffic Control Free Flight in 2015-2020
- Compatibility and interoperability with existing waveforms
  - *IEE Standards*
  - *EuroCAE and ARINC Standards*
  - *Military Standards*
  - *SEI Software Standards*
  - *CORBA Frame Architecture*

Currently deployed radio systems suffer from Inability to be easily upgraded

Key Architectural Approach

- Currently deployed architectures are generally not flexible, not providing common HW/SW elements for enhancements
- Architecture focus on scalability for application from GA through transports.
- Implementation of more digitally based design with A/D conversion moving closure to Apertures
- Software and Hardware differentiation becoming more blurred
  - *FPGA Code used for low latency, high speed applications*
  - *Software used in applications requiring change or upgrade*
- Security Barriers (Red/Black) implemented in both hardware and software

Expand the basic Software Defined Radio architecture with generic assets into specific hardware and software elements

Key Elements of MMDA/JTRS Approach

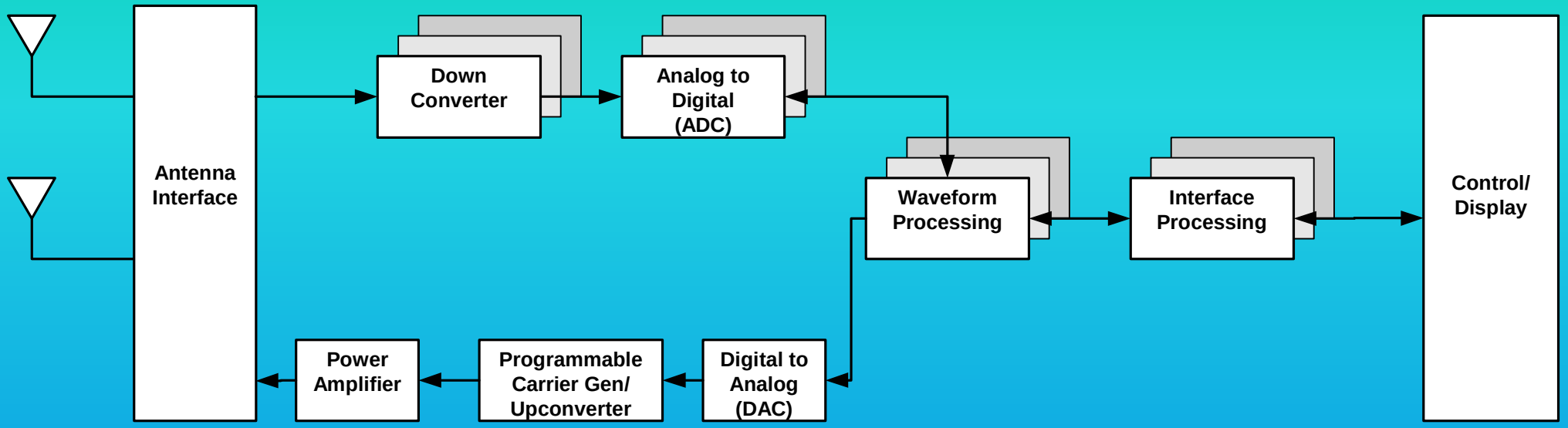
- Blend Military and Commercial products into multi-mode, multi-function cost effective commercial radio design
- Utilize DoD investment in JTRS and SAE Software technology as Leverage to Commercial Air Traffic Control applications
  - ***Implementation of key elements of similar military approaches***
  - ***Security of Air Traffic control waveforms***
- **Use of previously developed waveforms in MMDA hardware**
  - ***Implementation of current and future air traffic waveforms not currently part of the JTRS effort***
    - **Minimize the hardware impact**
    - **Simplified, low risk qualification approach**
- **Independence of Hardware and Software elements to allow future growth and technology insertion**

Cost reduction in Military programs still target costumers willing and able to pay for max performance

Key Elements of MMDA/JTRS Approach

- JTRS concepts do not identify specific implementation
  - ***User and waveform application interfaces are common across all implementations***
- The heart of interoperability is the JTRS goal based upon portable (standardized) waveforms
  - ***Vendor to vendor portability***
  - ***Software elemental independence (Changes to individual software elements do not effect other elements***
- **JTRS is developing 5 waveforms directly portable to the civil aviation environment**
  - ***HF ATC Data Link***
  - ***VHF-AM ATC***
  - ***VHF-AM ATC Extended***
  - ***VHF ATC Data Link***
  - ***Mode S Level 4/5***

SDR Generic Architecture

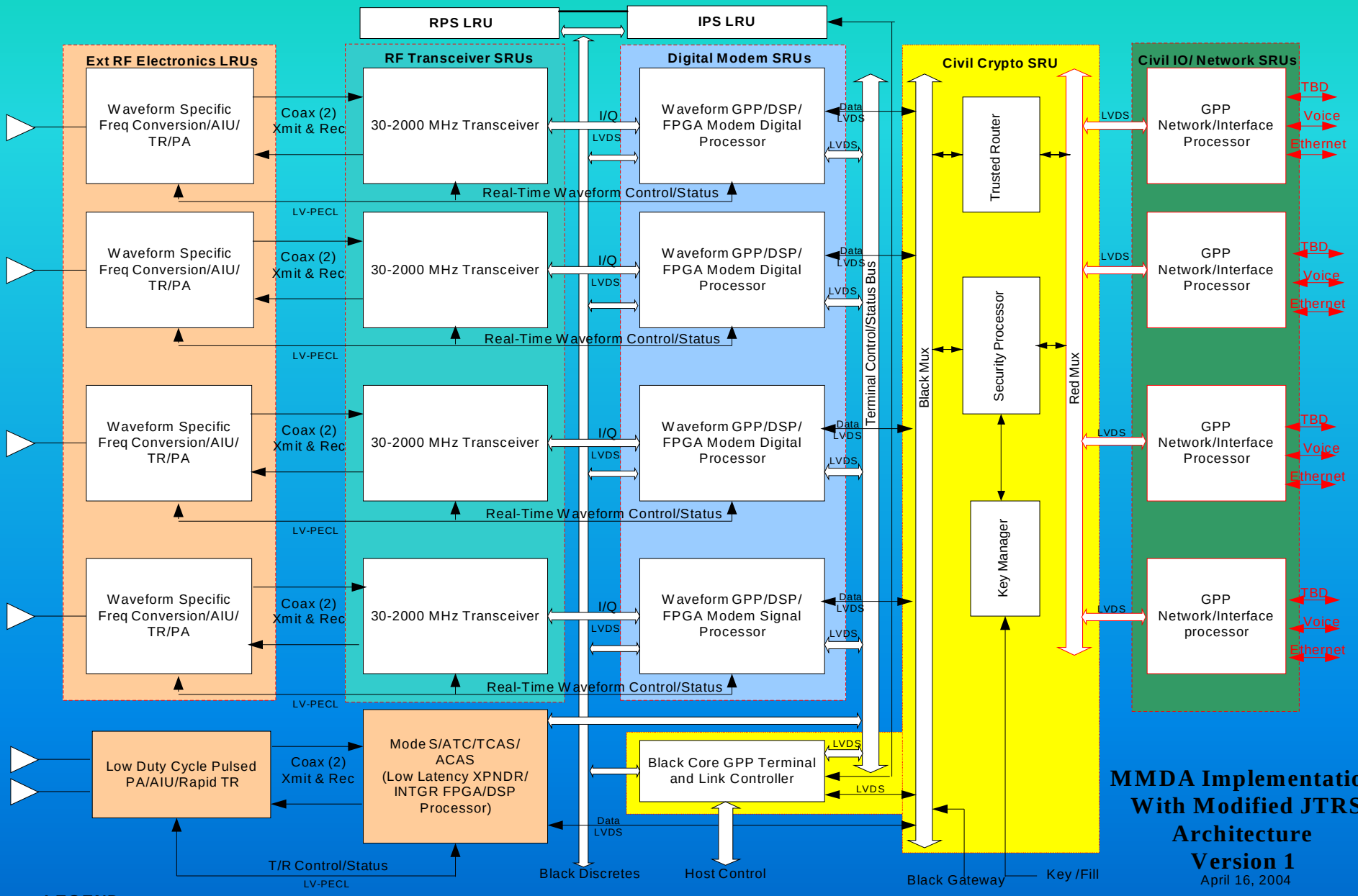


One or more Power Amps or a Multi-mode Power Amp dependent on Functionality within MMDA

- Common Hardware/Open Architecture
- Commercial Level Cryptography
- SEI/SCA Based Software Architecture
  - OSIL/CORBA implementation

Multiple functionality and performance in the presence of failures

MMDA Candidate Architecture

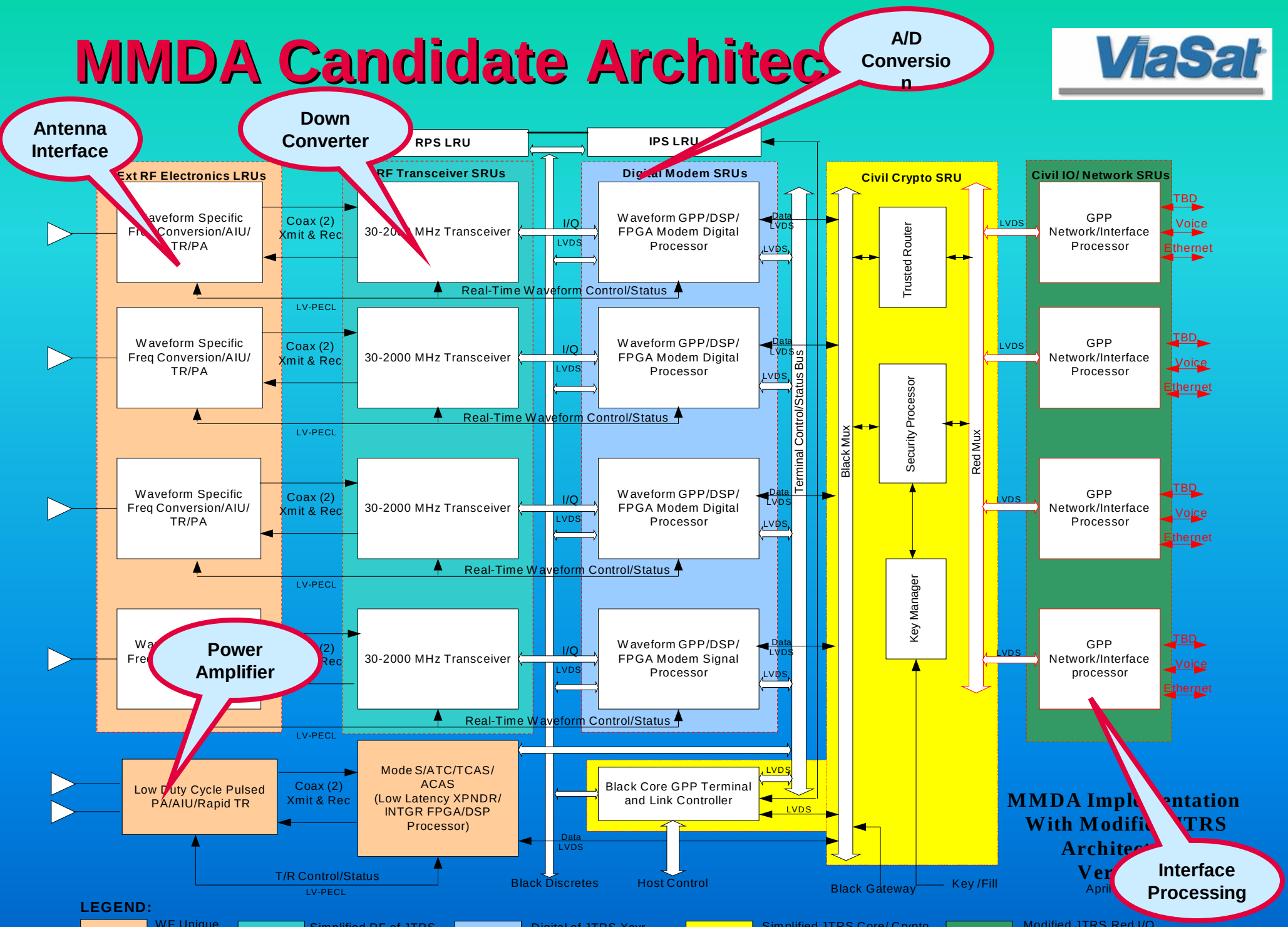


MMDA Implementation With Modified JTRS Architecture Version 1
April 16, 2004

LEGEND:

- WF Unique LRUs/SDUs
- Simplified RF of JTRS Xcvr SRUs
- Digital of JTRS Xcvr
- Simplified JTRS Core/ Crypto SRU
- Modified JTRS Red I/O SRUs

MMDA Candidate Architec



MMDA Implementation With Modified JTRS Architecture Ver

April

MMDA Performance Challenges

- **RF**
  - *Multiple Power Levels*
  - *Multiple Antenna Configurations*
  - *Spectral purity*
  - *Pulse shaping*
  - *Linearity*
  - *EMC Features*
  - *Dynamic Range*
  - *Interference Rejection*
  - *Hard-limited IF*

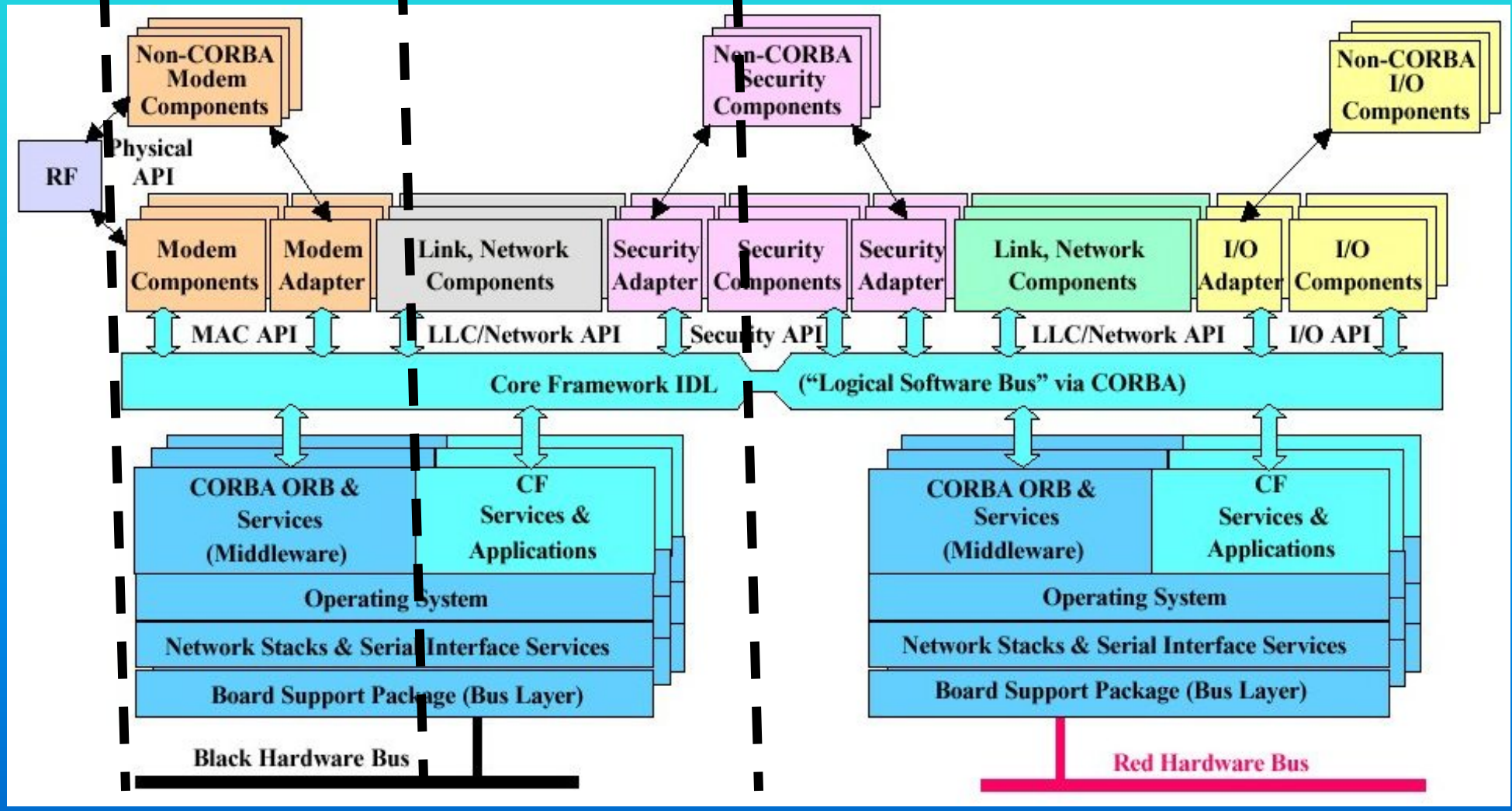
Issues with Mixed L band and U/V Band and beyond

- **Baseband**
  - *Security Timing*
  - *Round Trip Response time*
  - *Bus loading/Timing*
  - *Enhanced Throughput Performance*

"More power to the engines Scotty..."

SCA v2.1 Software Structure

Where does the dividing line for processing assets belong???



Security Issues

Future air traffic control may require more stringent security measures to prevent outsiders from influencing the system

- *More Data Link Contact*
- *Less Voice used for specific navigation and pattern control*

- Military Cryptographic devices may be overkill for commercial applications
  - *Unless software programmable cost may be prohibitive*
- Commercial Applications will require positive identification between aircraft and controllers
  - *Anti-Spoofing*
  - *Anti-Hi Jack*
- Multi-level Security implementation
  - *Imposes a security function on all processes (sorting of unclassified and secured data)*
  - *Application data with trusted labels to keep data compartmentalized*

Key enabling Technologies

- **Architecture…….not hardware**
  - ***JTRS hardware design will not meet the commercial cost model***
  - ***Adapt portions of architecture and hardware design appropriate for commercial application***
  - ***Mechanical Design consistent with scalable system for applications to both general aviation as well as commercial transport***
- **Receiver and Power Amplifier Issues**
  - ***VHF only***
  - ***Multi-band, broad range, multi channel capability***
- **RF and Digital Processing Elements perform very complex functions over a broad spectrum of algorithms, bandwidths and security levels**
- **Low cost/High density packaging techniques**
  - ***Multi-chip packages***
  - ***Reduction of specialized RF circuitry (i.e. digital filtering etc.)***

Applying Architecture to HW

- **Software vs. Hardware implementation**
  - *Functions requiring critical timing for functional performance are implemented in Hardware*
  - *Functions with algorithms unlikely to change are implemented in hardware*
  - *Functions or operations likely to be upgraded or changed over time are implemented in software*
- **RF vs. Digital Implementation**
  - *Mechanical considerations may overrule other considerations*
  - *Many traditional RF Functions can be implemented now with Software*
- **Independence of Software Elements**
- **Independence of Hardware Elements**

Technology Rollover has potential impacts on MMDA design Approach
Digital Technology is rolling in as little as 14 months while
RF Technology may cycle every 7-15 years

Key Attributes

- Upgradeability of hardware and software with minimal impact
- Porting of appropriate waveforms to MMDA without hardware changes
- Graceful degradation of performance due to hardware failures
  - *Multiple Receivers and processors allow automatic reconfiguration of prioritized functions*
- Reconfiguration of system based on Geographic location of aircraft

Qualification Issues

- **Traditional Approach does not test beyond specification limits**
- **Test Early….Test Often**
  - ***Independence of software from hardware***
  - ***Functional independence***
  - ***Key interfaces verified to open architecture standards***
- **Stress testing of Busses, power, and key performance areas**
- **Test to Failure**
  - ***Discovery of performance limits of both software and hardware***
  - ***Manufacturing and design margins***
- **Performance in the presence of Failures**
  - ***Addition of new functions in environment with sub optimum performance***
  - ***Proves independence of each of the key functional elements in the system***

Use NASA Aeronautical Research Simulator (ANRS) to test MMDA in realistic Flight/RF environment

MMDA Architecture Summary

- Take the best design attributes from JTRS. Hardware elements as designed will not meet hardware cost goals
- Provides path for future enhancements that minimize qualification risk and schedule (cost)
- Mechanical engineering aspects will have significant impact on final MMDA design
  - *Volume, Cooling, Cost*
  - *Analog Filters most power efficient than DSP techniques*
- TBD

Utilization of Waveforms and Architecture and not the Physical deign are the critical elements to applying JTRS architectures to MMDA